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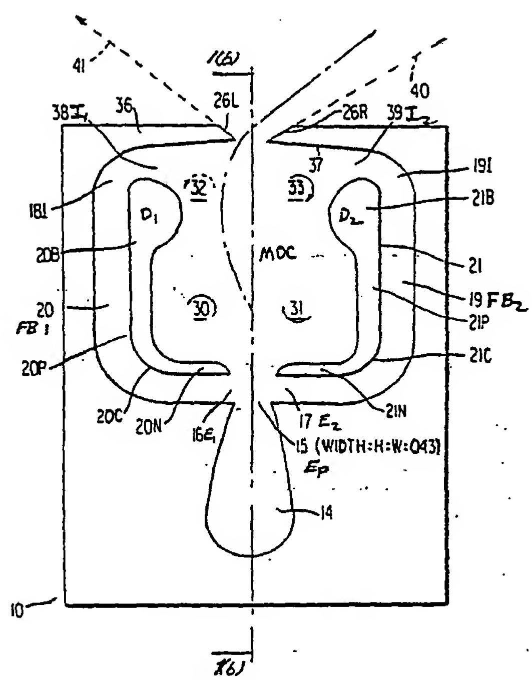
(54) Title: LIQUID OSCILLATOR DEVICE

(57) Abstract

The liquid spray device includes an oscillator for producing a fan spray with liquid droplets of uniform size. The oscillator is constituted by a power nozzle (15), a pair of side walls (20, 21) forming a pair of vortex spaces (30, 31) offset from the power nozzle, a pair of inwardly extending protuberances or deflectors (20B, 21B) downstream of which are a pair of inlets (181, 191) to passages (18, 19) leading to exits (16, 17) adjacent the power nozzle, and an outlet throat or aperture (24) having a pair of short wall surfaces (26L, 26R) defining an exit throat of any value selected from about 30o to about 160o so that the fan angle can be selected to be from about 30o to 160o. This structure results in an oscillator which has a relatively low threshold of pressure at which oscillations are initiated and, most importantly, the liquid is issued in a much more uniform fan pattern that heretofore possible. In a preferred embodiment the liquid is a windshield washer fluid and the oscillator is incorporated in a nozzle for an automobile windshield washer assembly for issuing a fan spray of washer fluid onto the windshield.



LIQUID OSCILLATOR DEVICE

Reference to Related Application

This application is a continuation-in-part of U.S. application Serial No. 112,248 filed January 14, 1980 and entitled "Nozzle for Automobile Windshield Washer Assembly".

Brief Description of the Invention and its Background

In the prior art liquid oscillator nozzles as disclosed in the application of Harry C. Bray, Jr., entitled "Cold Weather Fluidic Fan Spray Devices And Method" U.S. Application No: 959,112 filed November 8, 1978, (the disclosure of which is incorporated herein by reference) and the oscillators disclosed in Bauer patents 4,157,161, 4,184,636 and Stouffer et al patents 4,151,955 and 4,052,002, and Engineering World, December 1977, Vol. 2, No. 4 Page 1, (all of which are incorporated herein by reference) liquid oscillator systems are disclosed in which a stream of liquid is cyclically deflected back and forth, and in the case of patent 4,157,161, Engineering World, and the above application of Bray, the liquid is a cleaning liquid compound directed upon the windshield of an automobile system. In those which have the coanda effect wall attachment, or lock-on (Engineering World, for example) there is a dwell at the ends of the sweep which tends to make the fan spray heavier at ends of the sweep than in the middle. Such system works very well where a single nozzle is used to provide a fan spray from the center of the windshield as in the system disclosed in Engineering World system.

The basic object of the present invention is to provide a liquid oscillator element which produces a fan spray in which the liquid is relatively uniform throughout

the fan spray thereby resulting in a more uniform dispersal of the liquid.

For example, in a preferred embodiment, the liquid is a windshield washer fluid which is sprayed on an automobile windshield and the uniform droplets provide a better cleaning action. In addition, the oscillator in the present invention retains the desirable low pressure start features of the prior art as well as and cold weather start characteristics of the oscillator disclosed in the above mentioned Bray patent application.

Thus, a further object of the invention is to provide an improved liquid oscillator for automobile windshield washer systems.

SUMMARY OF THE PREFERRED EMBODIMENT OF THE INVENTION

The preferred embodiment of the invention is carried out with an oscillator constituted by a generally rectangular chamber having at the upstream end an inlet aperture for a power nozzle, an outlet aperture or throat coaxially aligned with the power nozzle or inlet aperture, the outlet aperture also having a pair of short boundary walls which have an angle between them of approximately the desired fan angle of liquid to be issued. The fan angle, as disclosed in the prior art referred to above, is related to the distance between the power nozzle and the outlet throat. A pair of spaced walls extending downstream of the power nozzle and spaced therefrom terminate in a pair of bulbous protuberances or deflecti~~ons~~ors which define the downstream ends of vortex forming spaces and the deflectors also define the vortex controlled entranceways to the inlets of a pair of liquid passages, the exits for the passages being at opposite sides of the power nozzle. While it is not critical for the proper operation of the present invention, one of the upper and/or lower walls bounding the oscillation chamber is tapered to assure cold weather oscillation.

BRIEF DESCRIPTION OF THE DRAWINGS

The above and other objects advantages and features of the invention will become more apparent when considered with the accompanying drawings wherein:

Figure 1(a) is a silhouette of a preferred form of the oscillator, and Figure 1(b) is a sectional side elevational view of Figure 1(a),

Figure 2 is a view similar to Figure 1(a), but wherein legends have been applied and some of the numbering deleted for clarity and there is shown the positions of three of the vortices and the location of the power jet at a particular instance during operation thereof,

Figures 3a-3h diagrammatically illustrate a sequence of vortex formation and movement and resulting flow conditions in an oscillator incorporating the invention and,

Figure 4 illustrates the droplet formation due to the sweeping action of the power jet.

DETAILED DESCRIPTION OF THE INVENTION

The invention will be described in relation to automobile windshield washer assemblies, the oscillator of the present invention is constituted by a molded plastic body member 10 which would typically be inserted into a housing or holder member 11 (shown in section Figure 2) which has a fitting 12 which receives tubing 13 connection to the outlet of the windshield washer pump (not shown). Liquid washing compound is thus introduced to the device via power nozzle inlet 14 which thus issues fluid through power nozzle 15. The liquid issues from the power nozzle 15 which at its exit EP has a width W, the liquid flowing initially past the exit ports 16 and 17 of liquid passages 18 and 19 respectively. Elements 20 and 21 basically form the boundaries of the interaction chamber and the liquid passages 18 and 19, respectively. This

chamber structure is defined by a pair of walls 20-N and 21-N which are normal to the central axis through the power nozzle 15 and outlet throat 24, which connect with wall elements 20-P and 21-P which are parallel to the direction of fluid flow, the wall elements normal and parallel wall elements being joined by curved section 20-C and 21-C respectively so that the liquid passages from the inlets 18-I and 19-I respectively are of substantially uniform width and about equal to the width W of the power nozzle. An important feature of the invention are the bulbous protuberances or projections 20-B and 21-B at the downstream ends of parallel portions 20-P and 21-P which preferably have smoothly rounded surfaces. Protuberances 20-B and 21-B with outer wall portions 36 and 37 define the entranceways 38 and 39 to inlets 18-I and 19-I, respectively. The outlet throat 24 has a pair of very short diverging fan angle limiting walls 26-L and 26-R, which in this embodiment are set at an angle of about 110° and which thereby defines the maximum fan angle.

While the basic structural features of the invention have been described above in relation to the invention; the following description provides relates to the functional characteristics of each of the major components of the invention

POWER NOZZLE (PN)

Figure 1 shows that in the device the walls WP of the power nozzle, are not parallel to the power jet centerline, but converge increasingly all the way to the power nozzle exit EP, so that the power jet stream will continue to converge (and increase velocity) until the internal pressure in the jet overides and expansion begins.

THE MAIN OSCILLATOR CHAMBER

The main oscillator chamber MOC includes a pair of left and right vortex supporting or generating volumes which vortices avoid wall attachment and boundary layer effects and hence avoids dwell of the power jet at either extremity of its sweep; the chamber is more or less square. The terms "left" and "right" are solely with reference to the drawing and are not intended to be limiting.

FEEDBACK PASSAGES

Exits (16', 17')

The feedback passage exits 16 and 17 (Figures 1 and 2) are not reduced in flow area. A reduction in flow area is sometimes used in prior art oscillators to increase the velocity of feedback flow where it interacts with the power jet; to restrict entrainment flow out of the feedback passage; or as part of an RC feedback system to determine power jet dwell time at an attachment wall. In the preferred embodiment of the invention, the feedback passage exits 16 and 17 of the oscillator are the same size as the passages 19 and 20. No aid to wall attachment is necessary because there are no walls on which attachment might occur.

Inlet (18-I and 19-I)

The feedback inlets in many prior art oscillators are sharp edged dividers placed so that they intercept part of the power jet flow when the power jet is at either the right or left extreme of its motion. The dividers used in prior art oscillators at the feedback inlet direct a known percentage of the flow to the feedback exit (or feedback nozzle in some cases) in order to force the power jet to move or switch to the other side of the device. The feedback passages sometimes contain "capacitors" to delay the build-up of

feedback pressure in order to lengthen the time the power jet dwells at either extreme. In contrast the feedback inlets 18-I and 19-I on this invention are rotated 90° relative to the usual configuration, and thus do not intercept any power jet flow. In fact, as will be described later under the heading "Method of Oscillation", there is no power jet flow in the feedback passages 19 and 20.

DEFLECTORS (PROTUBERANCES 20B AND 21B)

The partition that separates feedback passage from the main chamber MOC of the oscillator may also be seen in Figure 2, this partition is terminated at the feedback passage inlet by rounded protrusion or deflector members 20-B and 21-B. This part of the partition has three functions; to deflect the power jet stream; to provide a downstream seal for the vortex generation chamber; and to form part of the feedback passage inlet.

METHOD OF OSCILLATION

Initially as the supply pressure applied to the inlet 14 of the oscillator is increased, the power jet leaving via EP becomes turbulent. Liquid from the power nozzle EP issues therefrom toward the outlet throat and expands to fill the oscillation chamber MOC. The turbulence which begins on the free sides of the jet causes some entrainment of local fluid in the main chamber MOC, and eventually sufficient instability in the pressure surrounding the jet to cause it to begin to undulate. This movement increases with increased pressure until the jet impacts the deflectors and then the normal oscillation pattern for this device begins.

In this invention there are four places where vortexes can exist. These locations, (30, 31, 32, 33), may be seen in FIgures 1 and 2. However, only three vortexes

exist during most of the cycle, only two during the feedback portion of the cycle, and never four at the same time.

Assuming the power jet has just arrived at the left side of the device in Figures 2 and 3a, the vortex formation in left vortex generation chamber has just begun. The deflector 20B has formed a seal between the power jet and the rest of the chamber, so that the only place chamber MOC can get a supply of flow to relieve the low pressure generated there would be from the feedback passage FB1. With normal feedback this would occur because the feedback inlet would be receiving flow at a rate greater than the entrainment flow out of the feedback exit, and the power jet would move toward the opposite side. However, in this invention the inlet 18-I to the feedback passage is sealed by a strong vortex entranceway 38. This vortex at entranceway 38 was larger (like the one at entranceway 39) until it was confined in the feedback inlet by the power jet. Being suddenly reduced in size, its rotational speed increased, enhancing its ability to seal the feedback inlet 18-I and to deflect the power jet toward the outlet device to ambient. Meanwhile, since the vortex forming in the left vortex chamber has no flow to relieve the low pressure but the power jet, it builds in intensity. The increasing pressure unbalance across the power jet and the motion of the vortex cause the power jet to move further left (Figures 3_b, 3_c and 3_d) and to begin to impact the deflector 20B more on the upstream side. As this condition increases the power jet deflects off the deflector at a more shallow angle permitting the vortex 32 at entranceway 38 to expand. Thus, the outlet stream begins to move before feedback begins.

As the power jet moves into the left vortex chamber

it flows right across the lower end of the partition forming the feedback passage exit 16 following the contour of the partition 20P and at the same time, by aspiration, greatly reducing the pressure in feedback passage 20. The continual lowering of the pressure in the feedback passage, combined with the loss in energy of the vortex 32, results in the vortex suddenly being "swallowed" (Figure 3_e) into the feedback passage 20 and dissipating there.

When the vortex 32 is "swallowed", flow can take place in 20. The motivation for this flow is not from the usual positive pressure at the feedback inlet, generated by splitting off part of the power jet, but it is due to a low pressure in the feedback passage 20 generated by the high velocity power jet aspirating fluid from 20 at 16. The effect of feedback flow is:

1. Permits the power jet to receive entrained flow (through 20), so it can begin to move away from the partition at 16.

2. The additional flow (power jet plus entrained flow) tends to push the vortex 30 in the left vortex chamber downstream.

3. The flow through 20 to 16 creates a low pressure at 18 thus initiating a circulating flow from 16 to 18-I on the chamber side of the partitions 20P with the return through passageway 20 (Figures 3_c, 3_f, and 3_g).

4. The fluid motion described above, generates a pressure difference across the vortex 20 in the left vortex chamber. This push-pull effect causes the vortex 30 to cross-over deflector 20B and to move into the low pressure zone at entranceway 38 (Figures 3_f, 3_g, and 3_h).

5. The inlet 18-I is thus sealed once more upon the arrival of the vortex 32 (Figure 3_h). Feedback flow exists only during that period of time from the

annihilation of the vortex at inlet 18-I until the next vortex, from 30, moves into 18-I. During the remainder of the oscillator's cycle there is essentially no net flow through 20.

6. As the vortex 30 generated in the left vortex chamber moves across deflector 20B, it forces the power jet to the right side (Figure 3_g) where the power jet encounters the vortex 32 at entranceway 39 and the deflector 21B.

7. The CCW motion of the "new" vortex 32, as it crosses over deflector 20B, and the CW motion of the "old" vortex 32 at entranceway 39 cause the power jet to bend sharply and exit to the left. (Opposite to the condition shown in Figure 2).

8. When the power jet encounters the deflector 21B (Figure 3_h), a vortex 31 begins to form at the right vortex generation chamber (inlet 19-I is sealed by the "old" vortex 33) and the entire process described above is repeated.

The movement of the outlet stream is depicted in Figures 3_a through 3_h. As is shown in these figures, the outlet stream begins to move or sweep in an opposite direction by virtue of generation and movement of the vortices 30 and 31 and hence before fluid flow in the feedback passages. Therefore, the motion and position of the outlet stream is not entirely dependent on feedback, whereas the opposite is true, in astable multivibrators. The angular relationship (sweeping motion) of the output stream versus time is more closely related to sinusoidal oscillation than it is to astable oscillation. This is evidenced by the fact that the output stream does not "linger" at either extreme of its angular movement.

DROPLET FORMATION

The mechanism by which the droplets are formed begins

in the power nozzle. The convergency of the power nozzle generates turbulence in the power jet. Vortex shedding on the free sides of the power jet combines with the internal turbulence of the jet to generate an "organized" instability within the power jet. This instability or undulation within the power jet continues to build uniformly as the power jet approaches and passes through the exit. The frequency of the undulation being much higher than the frequency at which the power jet sweeps from side to side, provides a pattern very similar to that shown in Figure 4. This figure shows a calculated displacement versus time plot of the motion of the power jet stream as it exits the oscillator. For clarity the frequency ratio of the undulation in the power jet to the frequency of the power jet was set to 10:1 and the amplitude ratio 3:10. Figure 4 shows only one sweep of the power jet from left to right. The various maxima and minima that occur during the motion from left to right are labeled a through h. The number of degrees of motion of the jet that occurs between successive letters is quite different, however, the time between each is the same. It is therefore obvious that if the flow rate is constant, (which it is), then the amount of liquid distributed between C and D, for instance, is the same as between D and E. Since the amound of liquid distributed along these two paths is the same, then the size of the stream and thus the cohesive forces will be greater between D and E than between C and D. Applying the above argument to the entire picture, one would predict that as the liquid progressed away from the outlet the stream would part between A and B, C and D, E and F, and G and H. This is reasonable because of the higher tensile stress that exists between these points as compared to B and C, D and G and G and F. Therefore, the droplets would form

from the liquid contained in the latter group and the remaining liquid that flows into each area from the break points in the stream.

SUMMARY

The power nozzle design purposely generates turbulence in the power jet stream prior to the nozzle exit, rather than attempt to generate a "low" turbulence nozzle design with a controlled and stable velocity profile. Moreover, the power nozzle allows the power jet flow within the power nozzle to "hug" one or the other of the power nozzle's sidewalls in order to cause a closer interaction between the power jet and the exits 16 and 17 of the feedback passages 19 and 20, thus, enhancing the generation of very low pressures in the feedback passages.

The feedback passage exits 16 and 17 are unrestricted so there is no RC storage (e.g. capacitance or resistance effects) and permit maximum flow from the feedback passage. The large exits 16 and 17 also permit maximum aspiration to occur as a result of the power jet flowing across the exits. The feedback passages 19 and 20 are at a "low pressure-no flow" condition for most of the oscillator cycle.

Feedback is controlled by low pressure and vortex movement rather than intercepting a portion of the power jet. In fact, there is no power jet flow in the feedback passage. The entranceways 38 and 39 to feedback passage inlets 18-I and 19-I are designed to provide containment of a vortex for sealing the inlet to the feedback passage against flow.

The vortices produced in left and right vortex generation chambers dominate the process of oscillation and also provide a new vortex that moves into the inlet of a feedback passage to terminate each feedback occurence.

It is the vortex aided power jet control (as opposed to boundary layer or stream interaction) which is the dominant oscillatory mechanism controlling all major aspects. When a vortex moves across one of the deflectors, it forces the power jet toward the opposite deflector. In addition, this vortex, with help from a counter rotating vortex on the other side of the power jet, causes the power jet to bend sharply around the first vortex.

Since there is no wall lock-on or coanda effect utilized, there is essentially no dwell, a uniformity of fan pattern is achieved at the relatively wide angle (in the disclosed embodiment 110° to 120° however, I wish it to be understood that the fan angle can be any value from 30° to 160°) needed for good wetting , for example of a windshield, especially where separate driver and passenger nozzles are used. The fan is in the direct line of vision. At the same time, the device retains the low threshold pressure for initiation of oscillation so in the case of a windshield washer assembly for automobiles, there is no need to increase pump sizes for cold weather operation when the viscosity and surface tension of the liquid has increased. If desired, the oscillation chamber can have the top (roof) and bottom (floor) walls thereof diverging from each other in the direction of the outlet throat so as to expand the power jet in cold weather but it is not necessary in regards to the present invention.

The device illustrated is an actual operating device. Variations of the output characteristics can be achieved by varying the curvature of protuberances 20-B and 21-B. In addition, the fan angle can be decreased by shortening the distance between the power nozzle 15 and outlet throat 24. In the drawings, the distance between the power nozzle 15 and the outlet throat

24 is about 9W and the distance between side walls 20 and 21 is slightly more than 6W, the distance between protuberances 20-B and 21-B is slightly greater than 4W.

While the preferred embodiment of the invention has been illustrated and described in detail, it will be appreciated that various modifications and adaptations of the basic invention will be obvious to those skilled in the art and it is intended that such modifications and adaptations as come within the spirit and scope of the appended claims be covered thereby.

What is claimed is:

CLAIMS

1. In a liquid oscillator having an oscillation chamber, a power nozzle for introducing a liquid power jet into said chamber, an outlet throat downstream of said power nozzle and a pair of passages having inlet openings to the respective sides of said outlet throat and exit openings adjacent said power nozzle,

the improvement wherein said oscillation chamber includes a pair of mirror image wall surfaces begining immediately downstream of said exit openings and extending to downstream therefrom and defining vortex forming chambers, the downstream end of each said wall surfaces being shaped to permit vortices formed in said vortex forming chambers to move thereover into said inlets whereby said liquid power jet is caused to oscillate back and forth in said oscillation chamber.

2. The liquid oscillator defined in Claim 1 wherein said downstream ends are smoothly curved.

3. The liquid oscillator defined in Claim 1 wherein said power nozzle has converging sides and said power jet expands in said oscillation chamber.

4. The liquid oscillator defined in Claim 1 wherein said oscillation chamber has top and bottom walls which diverge, relative to each other.

5. The liquid oscillator defined in Claim 1 wherein said power jet creates a suction at the exit opening of the one of said pair of passages having a vortex residing in the inlet opening thereof.

6. The liquid oscillator defined in Claim 1 wherein said downstream ends are smoothly curved to merge into said inlet opening.

7. The liquid oscillator defined in Claim 6 wherein said power nozzle has converging walls such that said power jet expands in said oscillation chamber.

8. The liquid oscillator defined in Claim 7 wherein said power jet creates suction at the exit opening of said one of said pair of passages having a vortex residing in the inlet opening thereof.

9. The liquid oscillator defined in Claim 1 wherein said oscillation chamber is generally rectangular in shape, said vortex forming chambers being to each side of said power jet, respectively.

10. The liquid oscillator defined in Claim 8 wherein said oscillation chamber is generally rectangular in shape.

11. In an automobile windshield washer system having a supply of windshield washer liquid coupled to an oscillating spray nozzle and a pump for causing washer liquid from said supply to flow to said nozzle the improvement wherein said nozzle includes an oscillator as defined in Claim 1, and an outlet wall at each side of said outlet throat, limiting the fan angle of the liquid spray upon windshield of the automobile.

12. In a windshield wahser system having liquid fan spray nozzle, said nozzle including an oscillator having an oscillation chamber a power nozzle for introducing a liquid power jet into said chamber, outlet throat

downstream of said power nozzle and a pair of passages having inlet openings to the sides of said outlet throat and exit openings adjacent the power nozzle, the improvement comprising,

a pair of mirror image wall surfaces, each mirror image wall extending along one side of the axis of said power nozzle and beginning immediately downstream of said exit openings and shaped to define a vortex forming chamber,

and a pair of spaced apart protuberances connected to the downstream ends, respectively, of said walls,

the upstream surfaces of said protuberances being shaped to permit vortices formed in said vortex forming chambers to move downstream thereover into inlet openings of said passages,

whereby the liquid of said power jet is caused to oscillate in said chamber and does not lock-on to any wall surface and the pattern of liquid in said fan spray is substantially uniform.

13. The invention defined in Claim 12 wherein at least the upstream surface portions of said protuberances are smoothly curved.

14. The invention defined in Claim 12 wherein said protuberances are shaped to form vortex supporting entranceways between said outlet throat and the inlet openings to said passages, respectively.

15. In a windshield washer system having a liquid fan spray nozzle, wherein said nozzle includes an oscillator having a power nozzle for introducing a liquid power jet into a chamber, outlet throat downstream of said power nozzle and a pair of passages having inlet openings adjacent the power nozzle, said fan spray being issued

from said outlet throat, the improvement comprising,

a first pair of walls normal to the axis of said power nozzle and located immediately downstream of said exit openings,

a second pair of walls parallel to the axis of said power nozzle connected to said first pair of walls immediately downstream thereof,

and a pair of spaced apart, protuberances connected to the downstream end of said second pair of walls,

whereby the liquid of said power jet does not lock-on to any wall surface and the pattern of liquid in said fan spray is substantially uniform.

16. The invention defined in Claim 15 wherein said bulbous protuberances are smoothly curved.

17. The invention defined in Claim 15 wherein said bulbous protuberances are shaped to form vortex supporting entranceways between said outlet throat and the inlet openings to said passages, respectively.

18. A fluid oscillator comprising in combination,

a power nozzle,

an oscillation chamber for receiving fluid from said power nozzle and being constituted by a pair of vortex inducing spaces, each vortex generating space having an upstream end, a downstream end an element connecting said downstream end with said upstream end,

means forming a pair of passages at each side of said chamber, each passage having an inlet opening end adjacent the downstream end of said vortex generating space and an exit opening adjacent to said power nozzle,

means forming an outlet throat downstream of inlet opening end,

whereby vortices rythmically induced in said vortex spaces move to said inlets and a negative pressure is induced at the exit openings of said passageways by fluid flow from said power nozzle until the vortex in said inlet is swallowed into said passage.

19. A method of causing a liquid jet to sweep back and forth comprising

issuing a liquid jet into a chamber having mirror image vortex forming spaces to create oppositely rotating vortices, and an outlet,

causing said vortices to alternately move downstream to block respective entranceways to passages leading to exits adjacent the point of issuance of said liquid jet into said chamber and initiate the deflection of said liquid jet in said chamber and

causing said jet to alternately aspirate said exits until the vortice blocking said entranceway is swallowed into the passages it is blocking, whereby said liquid jet is caused to deflect back and forth in said chamber and sweep back and forth on passing through said outlet.

1/4

FIG 1(b)

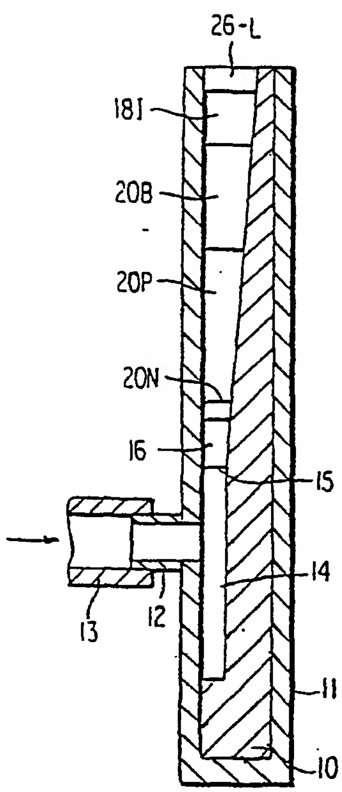
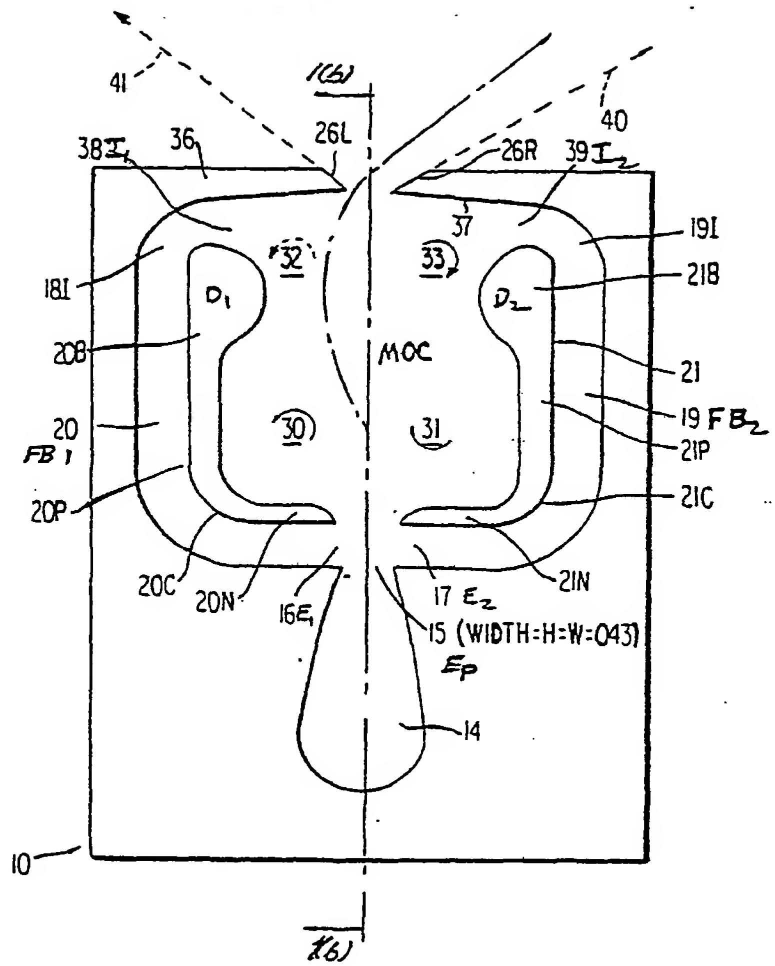


FIG 1(a)



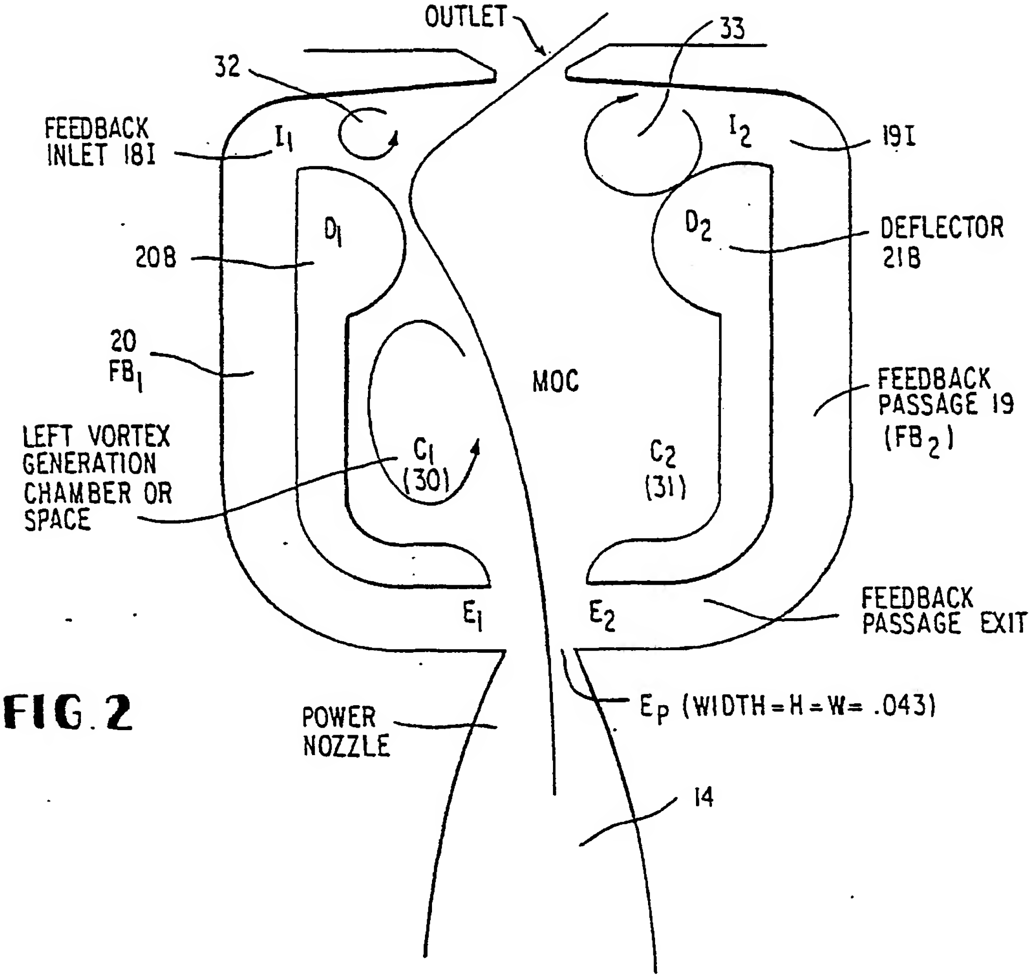

OUTLET
32
33
FEEDBACK INLET 18I
I1
I2
19I
D1
D2
DEFLECTOR 21B
20B
20 FB1
MOC
FEEDBACK PASSAGE 19 (FB2)
LEFT VORTEX GENERATION CHAMBER OR SPACE
C1 (30)
C2 (31)
E1
E2
FEEDBACK PASSAGE EXIT
POWER NOZZLE
Ep (WIDTH = H = W = .043)
14

FIG. 2

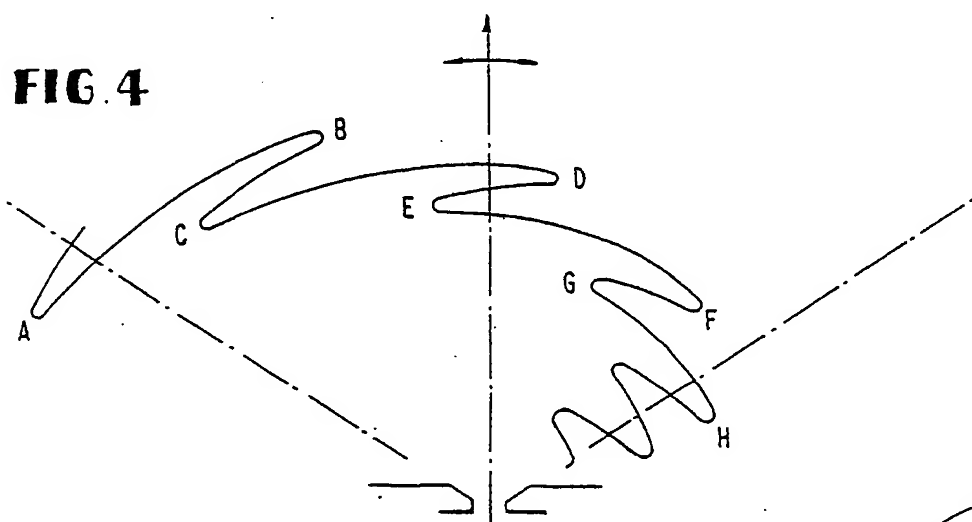

A
B
C
D
E
F
G
H

FIG. 4

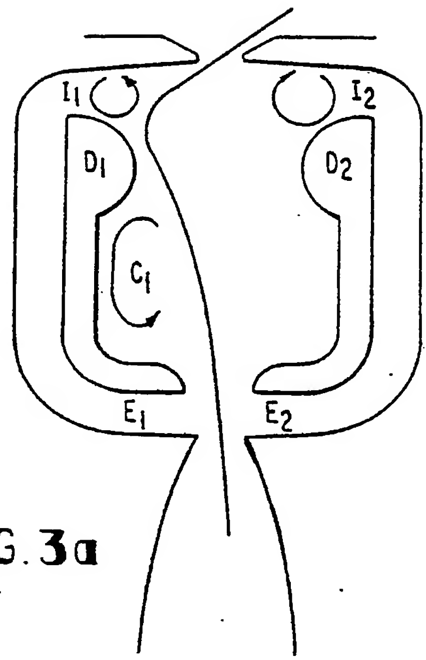


FIG. 3a

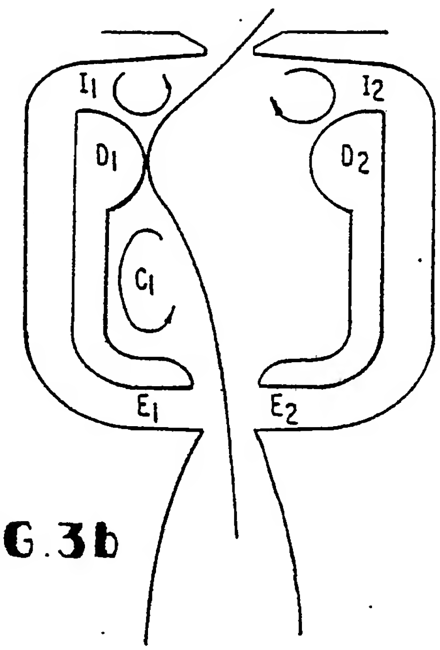


FIG. 3b

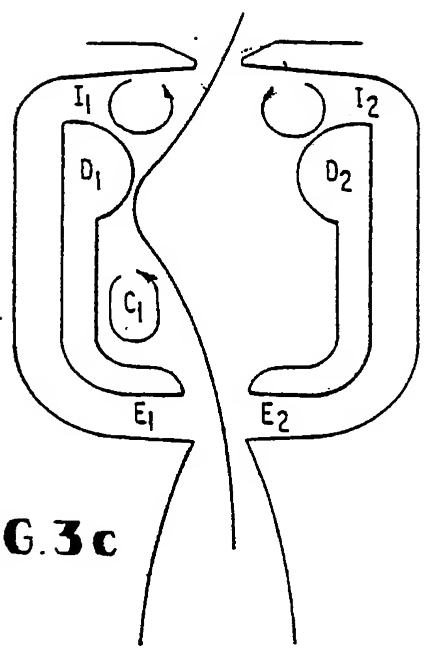


FIG. 3c

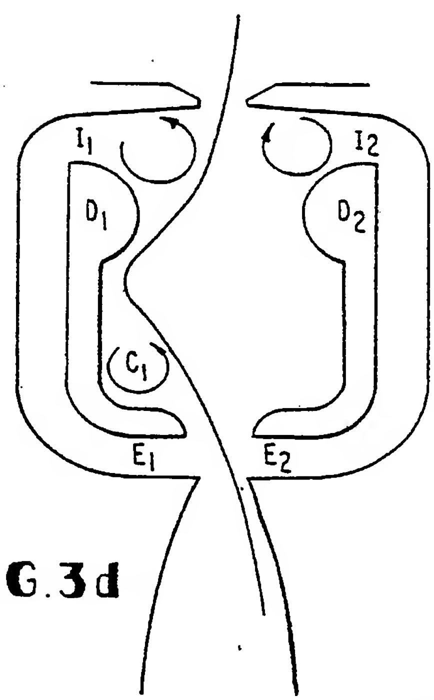


FIG. 3d

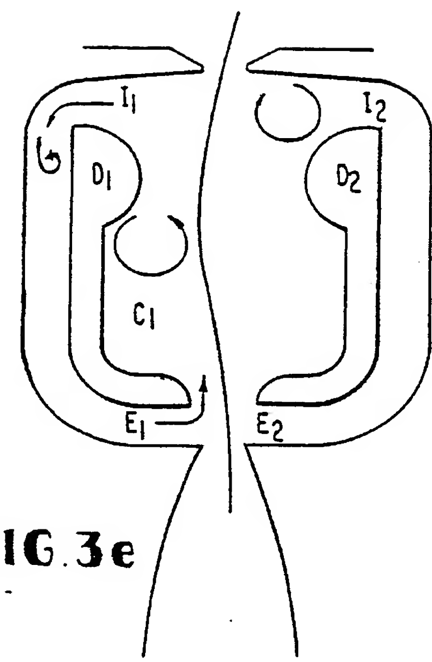


FIG.3e

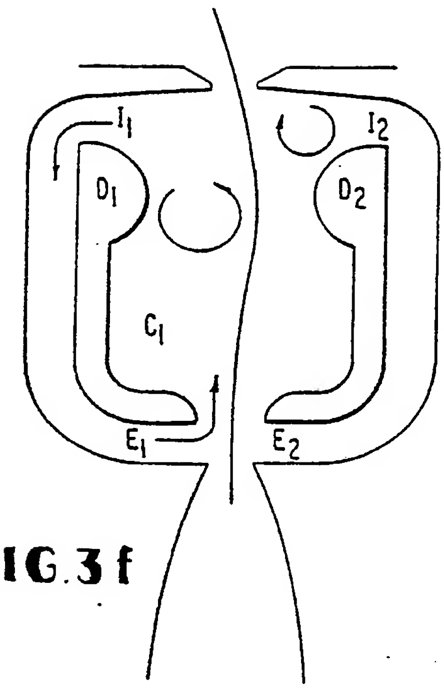


FIG.3f

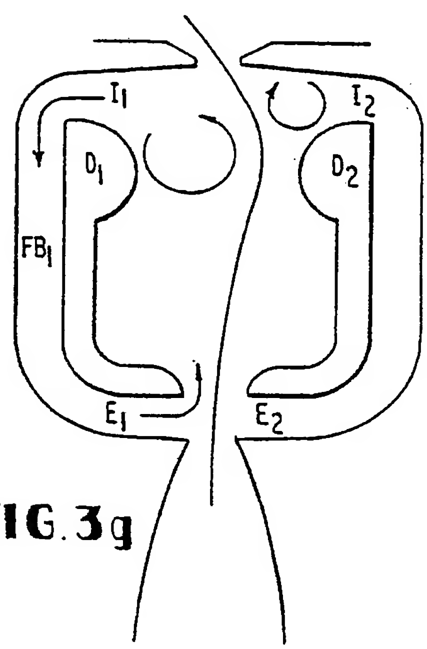


FIG.3g

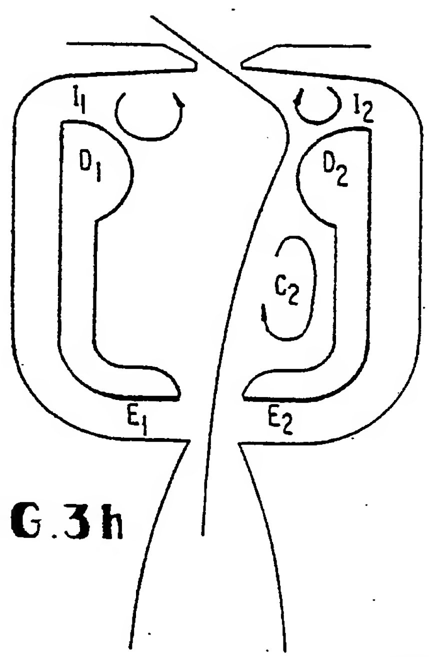


FIG.3h

INTERNATIONAL SEARCH REPORT

International Application No PCT/US81/00047

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) [3]

According to International Patent Classification (IPC) or to both National Classification and IPC

Int. Cl.[3] B05B 1/08
U.S. Cl. 239/11,284R, 590; 137/835

II. FIELDS SEARCHED

Minimum Documentation Searched [4]

Classification System	Classification Symbols
U.S.	239/11,101,102,284R,589,590, Dig. 3; 137/808,809,811,833-835,839

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched [5]

III. DOCUMENTS CONSIDERED TO BE RELEVANT [14]

Category *	Citation of Document, [16] with indication, where appropriate, of the relevant passages [17]	Relevant to Claim No. [18]
	US,A, 3,423,026, Published 21 January 1969, Carpenter	1,5,11
	US,A, 3,432,102, Published 11 March 1969, Turner et al	1,19
	US,A, 4,052,002, Published 04 October 1977, Stouffer et al	1,3,18-19
A	US,A, 4,151,955, Published 01 May 1979, Stouffer	1,3,5-19
	US,A, 4,157,161, Published 05 June 1979, Bauer	1,11-12,15, 18-19
P	US,A, 4,185,777, Published 29 January 1980, Bauer	1-3,6-7,9-19

* Special categories of cited documents: [15]

"A" document defining the general state of the art

"E" earlier document but published on or after the international filing date

"L" document cited for special reason other than those referred to in the other categories

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but on or after the priority date claimed

"T" later document published on or after the international filing date or priority date and not in conflict with the application, but cited to understand the principle or theory underlying the invention

"X" document of particular relevance

IV. CERTIFICATION

Date of the Actual Completion of the International Search [2]	Date of Mailing of this International Search Report [2]
27 April 1981	07 MAY 1981
International Searching Authority [1]	**Signature of Authorized Officer [10]**
ISA/US	J. Cherry J. Cherry

Form PCT/ISA/210 (second sheet) (October 1977)